lings grow, they exhibit a tendency to lean toward the most intense light available. This early leaning habit usually persists throughout the life of the plants and, because of the strain thus put upon the root system, often results in their ultimate uprooting and death.

Southwestern Forest and Range Experiment Station,
United States Forest Service,
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## THE RELATION OF BIRDS TO SEED DISPERSAL OF THE DESERT MISTLETOE

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Although the especially interesting relationship of birds to the dispersal of seeds of some of the Loranthaceae has been mentioned frequently, it may not be amiss to restate this role in connection with the dispersal of the parasite *Phoradendron californicum,* and also to record a few original observations.

A number of species of birds have been observed feeding on the fruit of the desert mistletoe. Any bird which even occasionally feeds upon the fruit would, to a greater or less degree, be involved in its dispersal. The most important bird would seem to be the silky flycatcher, *Phainopepla nitens,* which most obviously bears a close association to mistletoe dispersal. Other birds observed feeding on mistletoe are the western bluebird, western robin, and desert quail. To this list could be added the linnet, mocking-bird, sage and other thrashers, audubon warbler, and many other less important species. Probably a careful check upon feeding habits of many of the non-resident birds present in the desert during the winter months would show interesting results. It seems obvious that frugivorus birds and the insectivorous species which resort to fruit upon occasions when other food is not available, would find in *Phoradendron* an easily accessible emergency supply with which to eke out the scanty fare available in the desert during the winter months. As an emergency food supply or as a sole source of subsistence, the mistletoe offers an unique advantage to avian life on the desert. Unlike many of the desert products which are dry, bitter or pungent, the mistletoe provides a moderately juicy fruit free from the usual repellents found in desert plants, and one which is most remarkable for the long period during which it is available to desert fauna.

During April, 1935, while on a visit to Borego Valley, San Diego County, California, it was observed that the season's crop of berries was just ending, and at the same locality in November, 1935, the first fruit of the new season was just ripening. Apparently then, there is a period of six months when the berries are

available somewhere in any region where the mistletoe is abundant. It is true that at some time during this period, much of the mistletoe is in bloom, but at the same time many clusters are fruiting. This extended fruiting period is exceptional and is especially noteworthy in desert areas where in general fruiting seems to occur over only a short period. The method of seed dispersal of this important avian food crop would seem to be so effective as to make unnecessary the obviously enormous output of seeds.

Predicated on the usual basis of fecundity versus nurture, one would assume from the apparent abundance of seeds that their dispersal and placement would be poor. If, however, one observes the methods of dispersal and the effectiveness with which the seeds are spread about and attached to likely hosts, one can only assume that the percentage of survival must be low. Otherwise, production of seed would not be so great.

As a matter of fact, most of the very large crop of seed appears to be fertile. Certainly enormous numbers are successfully placed on the surface of living twigs of the host plant, yet only a very small proportion of the seeds which germinate ever succeed in continuing growth and becoming adult parasites. Practically all which fall upon living or even dead twigs germinate, as can be seen by even a casual scrutiny of the seeds found attached to the host. Because of its size and color the bright brownish-red radicle is conspicuous. Since most of the seeds appear to be fertile, and since germination and production of an attaching radicle seem almost universal, an explanation of the large seed production would appear to lie elsewhere than in nurture.

One serious loss of seeds is due probably to the common habit of many species of birds of perching on dead twigs, high above the rest of the tree. It has been noticed, for instance, that soon after feeding, bluebirds, and that most important distributor of seeds, the silky flycatcher, resort to the bare, topmost twigs in the immediate neighborhood of the feeding station. Most of these favorite perches are located over masses of dry twigs, apparently killed by an earlier mistletoe infestation. This habit of many birds, but especially of *Phainopepla,* has perhaps two interesting possibilities: many discharged seeds fall either on a dead twig (pl. XX, fig. 2) where they germinate in vain, or accumulate in piles (pl. XX, fig. 1) where apparently many fail to germinate. In either case, this perching habit of the carrier of the parasite results in a loss of a large number of seeds. It should be noted, however, that the same habit may have a favorable effect on the dispersal of the mistletoe. The very fact that the birds fly from the cluster of an established plant and seek out some other perch is important for dispersal, since through this habit there is an

increased exposure of other hosts to the infection. This trait may be effective also, provided that individual trees of the host plant vary in their resistance to the inroads of the germinating seed. Judging from the presence of parasite-free trees and of trees apparently killed by *Phoradendron,* this variation probably exists. Therefore, dying or dead twigs in a weakened tree by providing an invitation to birds, give an opportunity for reinfecting a host with fresh stock or for infecting weakened trees which may be subject to attack.

It is probable that trees vary considerably in their powers of resistance to these inroads. Some of the younger trees may be individually more resistant than others of the same age, but in general it is probable that older, time-weakened trees with bare, inviting twigs become most heavily infected.

That escape from the inroads of the parasite does not lie in chance alone is evident when the germinating seeds are studied in March and April, especially in the Colorado Lower Sonoran Zone, where at this particular time, they are still attached to the ironwood host. It will be noted that almost all the seeds have been pushed away from the intended host by a gum exudate which is produced by it (pl. XX, fig. 4). While the radicle of the seed may remain attached for a time, the constantly exuding and hardening gum eventually breaks connections between radicle and host, and the seedling dies. Within a short time this pillar of dry gum becomes brittle and breaks off. The radicle, even if by some chance it is still attached to the host, together with the remaining portion of the seed, is carried to the ground.

The question naturally arises as to what other factors are involved in the destruction of seeds, either through direct agencies as described, or through less evident means. Among the more obvious direct factors might be classed rodent action. It is well known that most rodents are voracious seed eaters and this seems to be particularly true of desert species. It is also true apparently, especially on the desert, that almost any nourishing organic matter may be utilized by these animals. It would, therefore, be expected that they would harvest those seeds which are distributed on the ground and also those dispersed along the twigs, thus protecting the tree from the inroads of the parasite.

After a careful examination of trees on which there was an abundant supply of attached seeds of the mistletoe, it became obvious that the few arboreal rodents present in the area do not consider these seeds an attractive food. Otherwise it is unlikely that there should be such accumulation as was found under *Phainopepla* perches. If rodents act as protectors of the host plant, it is probably purely incidental and due to their crawling along the branches in search of ironwood seeds and seedpods, or to obtain bark, twigs, and leaves. It may be, however, that

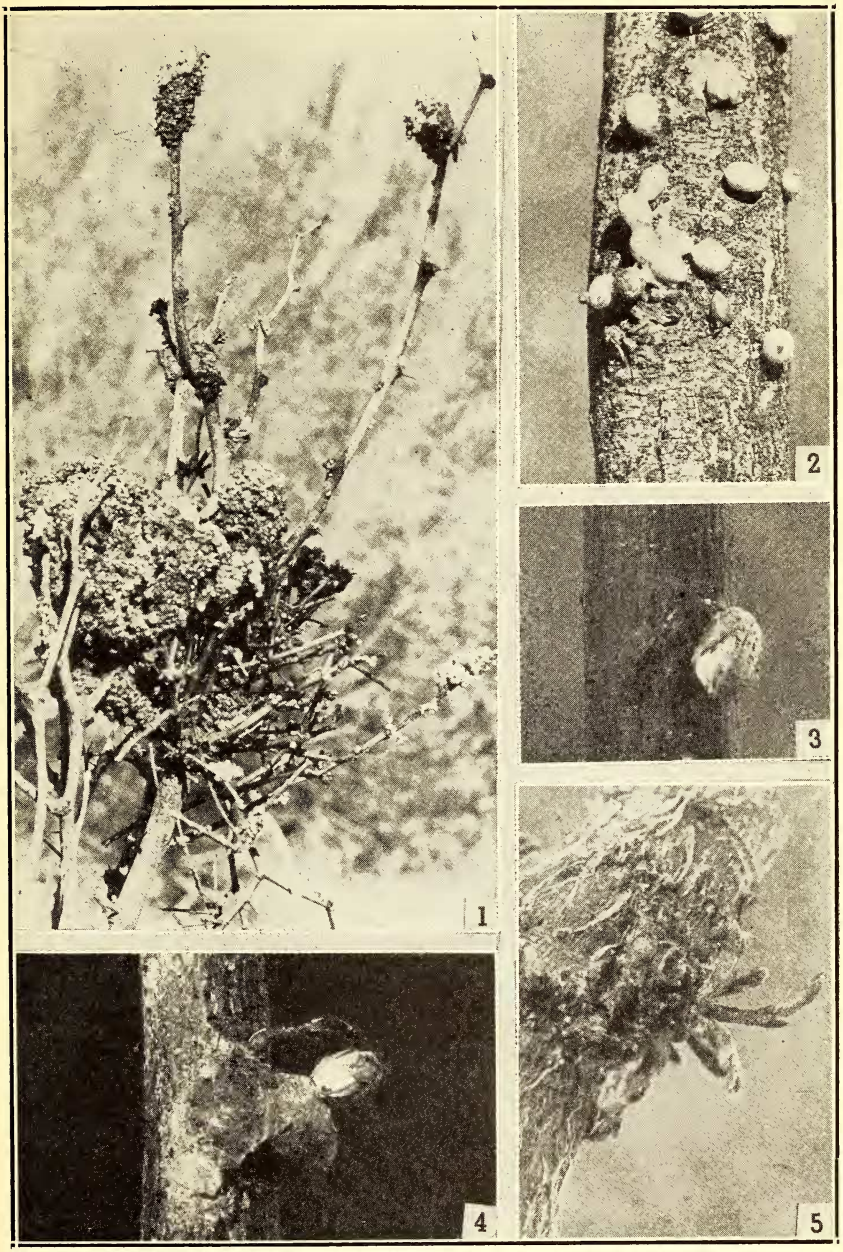


PLATE XX. PHORADENDRON CALIFORNICUM ON OLNEYA TESOTA. Fig. 1. Accumulated seeds on dead branch; deposited as feces of *Phainopepla*. Fig. 2. Seeds attached to dead twig; note radicle. Fig. 3. Seed attached to living twig. Fig. 4. Seed separated from twig by gummy exudate. Fig. 5. Newly established plant.

since they find ironwood bark to their liking, the gummy exudate present under the upraised seeds is also attractive to them. If this is true, their activity in searching out and collecting the gum might be serviceable to the tree, since it would be highly effective in breaking loose both seed and radicle. This possibility of rodent activity in conjunction with seeds is at present, however, purely conjectural. It may be of interest to note that a white rat found the seeds very distasteful, even though they had been macerated and combined with egg yolk.

An interesting study in the relative effectiveness of birds in the distribution of mistletoe is available to residents in desert areas where the parasite exists. This effectiveness would depend on three factors: use of the fruit for food; abundance of the species; habits of the species, that is, behavior subsequent to eating the fruit.

In the following comment the birds are mentioned in the probable order of their importance as distributors of mistletoe seed in Borego Valley. *Phainopepla,* a voracious feeder on mistletoe, is the most abundant species feeding on the plant. Furthermore, its perching habits are adapted most admirably to the role of seed distributor. Bluebirds feed on the fruit of the mistletoe and are moderately abundant during the fruiting winter months; their perching habits facilitate the dispersal of seed. Desert quail feed on the fruit voraciously. They are abundant throughout the fruiting period, but after eating, they return to the ground so are less important as effective distributors. Moreover, during feeding, these birds knock off large numbers of berries and frequently break loose whole twigs. In addition to these species which are most important in the economy of the parasite, others such as robins and thrashers might be mentioned but upon these few observations are available. Until continuous and more careful observations are made, any statement as to the value of many of the birds to the mistletoe would be purely conjectural.

University of California, Los Angeles,
April 6, 1936

## PLANTS DESCRIBED ORIGINALLY FROM CRATER LAKE NATIONAL PARK

F. Lyle Wynd

The following is a list of the plants known to have been described originally from Crater Lake National Park. The author studied these plants during several seasons at the Park.

Botrychium pumicola Coville, Underw. Nat. Ferns, ed. 6. 69. 1900. Growing in pumice soil on the summit of Llao Rock, Crater Lake, Oregon, at an elevation of about 9000 feet, *Coville*